



Examination Answer Books

12 Pages

Instructions to Candidates

1. Please give the information requested in the boxes below.
2. Enter your name in the space provided to the right, fold over the flap and seal down (using the label provided) to hide your name.
3. The answers must be legibly written. The Examiners can only read what you have typed and the expense of typing is charged to the candidate.
4. Write your answers in ink.
5. Begin each answer on a fresh page. Do all rough work in the answer book and cross it through.
6. No part of this book is to be torn out; it must be handed in complete.
7. If more books than one are used, fasten them together using the tags available from the invigilator(s).
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1	Student Number	2112087
2	Title of Examination Paper	Electromagnetic Radiation
3	Module Code	ACN15009
4	Date and Time of Examination	07/05/23 09:00
5	Examination Venue	360
6	Seat Number	008
7	Number of Answer Books handed in	1

[illegible]

(Gweler yr ochr arall am y fersiwn Cymraeg)

Q1, 3, 4

Question No.

Examiner Only

Q1 a) An electromagnetic wave is a wave comprised of an electric and magnetic component propagated at 90° from each other, it is self propagating in nature

2

b)

b) Properties of an EM wave are as follows:

- Can be polarised
- It is generally self propagating in nature
- The magnetic and electrical fields are 90° to one another (transverse)
- does not require a medium for propagation.
- travel with constant velocity in vacuum (approx speed of light)
- magnetic and electrical field oscillate in phase

2

4

c) an EM wave propagates via the phenomenon of magnetic to electric interaction, through this interaction, the wave can sustain propagation due to its interaction

1

d) The/An Electromagnetic spectrum is the term used to define wave wavelength and frequency, generally referring to Gamma, X-ray, UV, Visible light, Infrared, Microwaves and radio waves, in order of frequency - All of which travel at the speed of light.

1

Gamma = $> 30 \text{ EHz}$

X-ray = $30 \text{ PHz} - 30 \text{ EHz}$

UV = $30 \text{ PHz} - 750 \text{ THz}$

VL (Visible light) = $400 - 700 \text{ THz}$

IR = $300 \text{ GHz} - 450 \text{ THz}$

Microw = $300 \text{ MHz} - 300 \text{ GHz}$

Radio = $0 - 300 \text{ GHz}$

2

Radiowaves are defined as the shortest longest wavelengths, from thousands of kilometers down to approx. 1mm. This is divided into several categories internally - 535-1605 KHz for AM

waves and 88-108 MHz for FM waves - These waves were popularised as communications frequencies and were used as common broadcast frequencies for radio stations, radio wave is not exclusively limited to one way broadcasts, however

2

[continued later] (Q1d)

e) a TE mode, is sometimes referred to as an H-mode, only has a magnetic field along the direction of propagation - where E (Electric field) is perpendicular (or transverse) to the waveguides axis,

2

Philly C Westin

16

Q3

Question No.

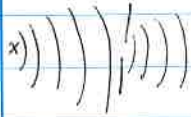
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i) diffraction is the term for the transformation of a wave around an obstacle ✓

ii) Similar to

iii,

iv



which demonstrates diffraction through a small slit ✓

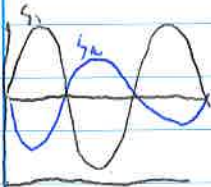
b) Total internal reflection is when a wave is entirely returned, for example, in a fibre optical connection where the difference between the external medium and the transmitted medium



is conducive to total reflection. ✓

c) Scattering is where a waveform compresses and decompresses (relative to itself) causing an interaction between the particles that differs depending on two separated models, whereby the particle either receives a strong rear force comparatively to the forward or the inverse, either way causing the particles in a wave to separate. ✓

d) Interference is where two waveforms interact with each other, reducing the relative net of signal strength, such as two frequencies being on the same frequency with different phases, as may be observed



as this provides a net negative on S_1 from S_2 , it provides interference. ✓

e) Refraction is related to reflection, as refraction is the transfer of energy back in off or a medium



as may be observed here, while not always total, refraction returns a portion of the original signal to the off the medium in contact. ✓

f) Waveguides are mechanisms used to manipulate the waveform, this can be affected in many different ways, ranging from direction to amplitude to, in some cases, the merging of signals some of the. ✓

Q3
2+2+1+2+1=8

Question No.

Examiner Only

Q2

Question No.

Examiner Only

- 9) Polarisation is a process of wave manipulation that can be observed frequently in everyday life - as items such as ~~phones~~, sunglasses and calculators all utilise polarisation.

A typical example in the modern technology space would be the polarisation of blue light. Both blue-light screen filters and ~~sunghases~~ are commonplace and work by utilizing a film that interferes with waves in the blue region of visible light.

Some polarisation techniques aim to normalise a waveform along a certain frequency or direction and some to merge waveforms.



- 11) Charge $Q_1 = -20 \mu\text{C}$ at $P(-6, 4, 6)$ and $Q_2 = 50 \mu\text{C}$ at $R(5, 8, -2)$

$$F_{Q_1 Q_2} = \frac{Q_1 Q_2}{4\pi\epsilon_0 d^2} \hat{a}_{RQ}$$

~~At R~~

$$\Delta x, \Delta y, \Delta z = 11, -4, -8$$

~~20 x 10⁻⁹~~

$$(-20 \times 10^{-9}) \times (50 \times 10^{-9})$$

$$\frac{11^2 + 4^2 + 8^2}{2} = d = 100.5 \text{ m}$$

$$4\pi \epsilon_0 100.5 (-20 \times 10^{-9})$$

$$\epsilon_0 = 8.854 \times 10^{-12}$$

$$(-20 \times 10^{-9}) \times (50 \times 10^{-9})$$

$$\frac{(-20 \times 10^{-9}) \times (50 \times 10^{-9})}{4\pi (8.854 \times 10^{-12}) (100.5 \times (-20 \times 10^{-9}))}$$

$$\approx 4.4715 \text{ V/m}$$

$$Q_2 = 3+2+1+1 = 7$$

Question No.

Examiner Only

Q4

Question No.

Examiner Only

A volume charge density is expressed as $10z^2x \sin \pi y$ find total charge.

a) $(-1 < x < 2) \quad (0 < y < 1) \quad (3 < z < 3.6)$

$\rho = 10z^2x \sin \pi y$

$Q = \int \rho dv$

$\int_{-1}^2 \int_0^1 \int_{3.6}^3$

Using (y) where $10z^2 \sin \pi y \Delta x \Delta y \Delta z$

$-1/\pi \cos \pi y$

$y = \int_0^1 1/\pi \cos \pi y / \pi \cos 0$

$10 \int_{-1}^2 x^2 \div 2 \int_{3.6}^3 x$

$10 \left(\int_{-1}^2 x^2 \div 2 \right) \times \left(\int_{3.6}^3 x \right) \times \left(-\cos \left(\frac{\pi y}{\pi} \right) \right) \int_0^1$

$(4 \div 2 - 1 \div 2) \times ((3.6^3)/3 - (3^3)/3) \times (-\cos \pi / \pi + \cos 0 / \pi)$

$=$
 $62.57 C$

b) Critical angle =

$\theta_c = \sin^{-1} \left(\frac{n_2}{n_1} \right)$

$n_2 = 1.47$

$n_1 = 1.50$

$\sin^{-1} \left(\frac{1.47}{1.50} \right)$

$\approx 1.37^\circ$ (S.S.F)

$a/r = 1$

d) an Isolator functions as a mechanism to isolate the ~~the~~ component of the waveform, typically to permit the usage of a more uniform output

e) a Laser is a form of directed, high intensity radiation that functions based off the principles of focused emission - through constructive interference, the waveform interacts with emitters within a laser to amplify the power output of the beam while retaining a narrow frequency, often narrow enough that the beam can retain a single visible colour

$$Q_1 \quad Z_{oc} = 50 \Omega \quad 2-60$$

and Z_{sc}

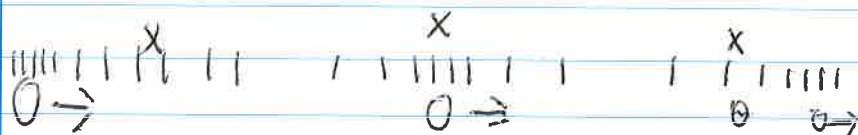
The lowest energy visible lasers tend to be red, while the highest visible tends to be violet - this mentioned as laser generally refers to light -
- i.e. visible light frequencies.

$$Q_4 \quad 4+2+1+3=10$$

have a good
day :)

a)

- b) The doppler effect refers to the difference in reading experienced from the wave emissions of a moving object/emitter. The typical example of the doppler effect is a moving ambulance, as it moves the siren of the ambulance is usually a higher ^{doppler} ~~pitch~~ when closer and less high when further away where O is the emitter and X is receiving



demonstrating that the nature of a continuously emitted wave appears to shift properties with varying distance

- c) a pulse radar works by emitting pulses at radio/microwaves aiming to either vary time by pulsing and emitting periodically or by emitting continuously at different frequencies. Both of these approaches take advantage of refraction/deflection and attempt to interpret this ~~incoming~~ return signal to draw an image of the scanned region via interpreting the strength of the returned signal.

2x
3x3=6

Question No.

Q1d) Radio is also used in 2-way communication, such as in 3G systems. The uniquely long wavelengths of Radio make it well suited to low throughput but long distance up and download that serve 3G systems well.

In addition to the Communications space, Radio astronomy is also an application of Radio, allowing the observation of phenomena not visible to standard equipment and, due to radio emissions being able to travel a great distance at a high speed and ~~thereby~~ incurring a lower level of interference due to objects - can allow for dating and observation of space objects otherwise unidentifiable.

[illegible]

Question No.

Examiner Only

Rhif y Cwestiwn

Arholwr yn unig